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Sustainable Agriculture

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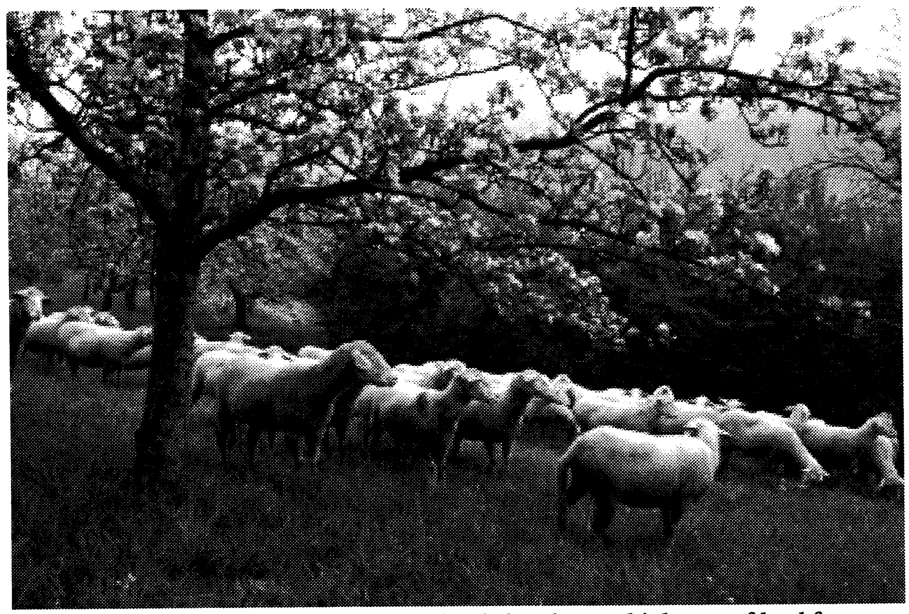

Sheep grazing on groundcover in an orchard showing multiple use of land for fruit and animal production.

Why Sustainable Agriculture?

Over the past decade, the term, "sustainable agriculture" has been defined in a variety of ways. This technical note clarifies what sustainable agriculture signifies for the Natural Resources Conservation Service (NRCS). A few basic concepts are presented to help the reader gain a better understanding of the topic, related philosophies and practices. This is the first in a series of technical notes on sustainable agriculture produced by the NRCS Watershed Science Institute. In later technical notes some basic procedures involved in converting to more diversified farming operations will be described.

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DEFINITION

In the 1996 Farm Bill, sustainable agriculture is defined as follows:

"...an integrated system of plant and animal production practices having a site specific application that will, over the long term—
(A) satisfy human food and fiber needs;
(B) enhance environmental quality and the natural resource base upon which the agricultural economy depends;
(C) make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
(D) sustain the economic viability of farm operations; and
(E) enhance the quality of life for farmers and society as a whole." (16 U.S.C. Sec. 3103(17))

The NRCS General Manual defines sustainable agriculture as:

"... a way of practicing agriculture which seeks to optimize skills and technology to achieve long-term stability of the agricultural enterprise, environmental protection, and consumer safety. It is achieved through management strategies which help the producer select hybrids and varieties, soil conserving cultural practices, soil fertility programs, and pest management programs. The goal of sustainable agriculture is to minimize adverse impacts to the immediate and off-farm environments while providing a sustained level of production and profit. Sound resource conservation is an integral part of the means to achieve sustainable agriculture." (180-GM Part 407)

The American Society of Agronomy defines it as agriculture:

"... that, over the long-term, enhances environmental quality and the resource base on which agriculture depends, provides for basic human food and fiber needs, is economically viable, and enhances environmental quality and the quality of life for farmers and society as a whole." (Schaller, 1990)

A fourth definition is:

"Sustainable agriculture is a philosophy based on human goals and on understanding the long-term impact of our activities on the environment and on other species. Use of this philosophy guides our application of prior experience and the latest scientific advances to create integrated, resource-conserving, equitable farming systems. These systems reduce environmental degradation, maintain agricultural productivity, promote economic viability in both the short and long term, and maintain stable rural communities and quality of life." (Francis & Youngberg, 1989)

These definitions, while not identical, have major components in common. Sustainable agriculture, under all four definitions maintains:

- PRODUCTIVITY
- ENVIRONMENTAL QUALITY AND ECOLOGICAL FUNCTION
- SOCIOECONOMIC VIABILITY

Prime Farmland

Stewardship of prime farmlands is a fundamental component of sustainable agriculture. Prime farmlands are highly productive, versatile, or otherwise unique and are of strategic importance to the nation as a whole as well as to individual regions ... Although total cropland in the United States has stayed nearly constant since 1945 at 460 million acres, the loss of farmland to urban and nonfarm uses can be a major local or state issue. Much of the best farmland is adjacent to major metropolitan areas and is being converted to nonagricultural uses.

- President's Council on Sustainable Development, 1996

Resource Efficiency

Energy is a critical resource for agriculture, yet it is not always considered in conservation planning. Sustainable agriculture attempts to minimize the use of non-renewable energy resources while increasing reliance on renewable energy resources.

To understand the role of energy in sustainable agricultural systems, consider the energy cycle of a farm compared with that of a natural ecosystem (Figure 2). The primary source of energy in both natural and agricultural ecosystems is the sun. Solar energy is converted by green plants to biochemical energy through the process of photosynthesis. This biochemical energy is then transferred to other organisms in the ecosystem through metabolism. At each level of transfer, energy is lost in the form of heat. In agricultural systems, solar energy inputs are subsidized by the addition of either "direct" energy inputs such as labor (animal and/or human), fossil fuels, and electricity used to perform farm work; or "indirect" energy inputs such as fertilizers, irrigation water, herbicides, pesticides, seeds and farm equipment. Energy is required to produce these indirect inputs. Energy "losses" also occur as soil, water and nutrients leave the system through erosion, runoff, leaching and denitrification. In natural systems these losses may be relatively minor. In agricultural systems, they may be substantial. One goal of sustainable agriculture is to economize on the energy subsidies to the agricultural system, utilizing the natural ecosystem as a model. To achieve this goal, farmers must make efficient use of non-renewable resources, use on-farm resources rather than purchased inputs when possible, and integrate natural biological cycles and controls where appropriate.

All of these components must coincide for agriculture to be sustainable. If a system is not ecologically sustainable, it cannot be productive or economical in the long run. Conversely, if a system is not productive and profitable over the long run, it cannot be sustained economically, no matter how ecologically functional (Neher, 1992). Sustainable agriculture also implies social and economic interactions among the producer, the community, and society as a whole.

PRODUCTIVITY

Sustainable agriculture produces safe, marketable food and fiber that is sufficient to supply the needs of the marketplace. Products of sustainable agriculture do not contain harmful residues nor exhibit pest damage that would significantly reduce market value (Fig. 1).

For society to be sustainable its agriculture must be productive. It is a misconception that sustainable agriculture is less productive than conventional agriculture. It may be more productive, especially in the long term.

Figure 1: Sustainable agriculture produces marketable food that brings profit to the farmer.

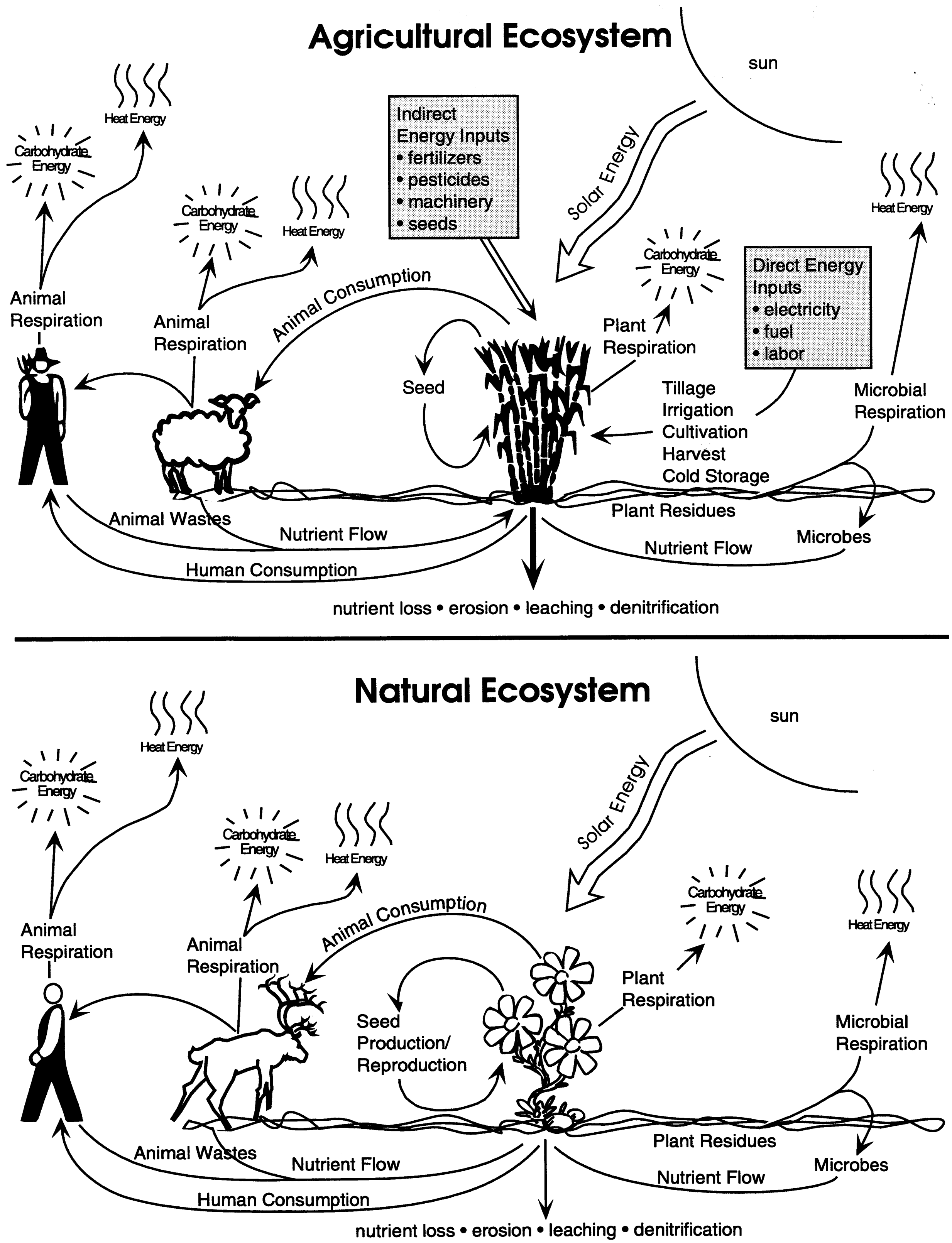

Figure 2: Energy Flows in Agricultural and Natural Ecosystems

ENVIRONMENTAL QUALITY AND ECOLOGICAL FUNCTION

Sustainable agriculture maintains and protects soil, water, air, plants, animals and cultural resources. It optimizes use of resources produced on the farm or within the local community, and it strives to minimize the depletion of **non-renewable energy resources** and optimize effective use of **renewable energy resources**.

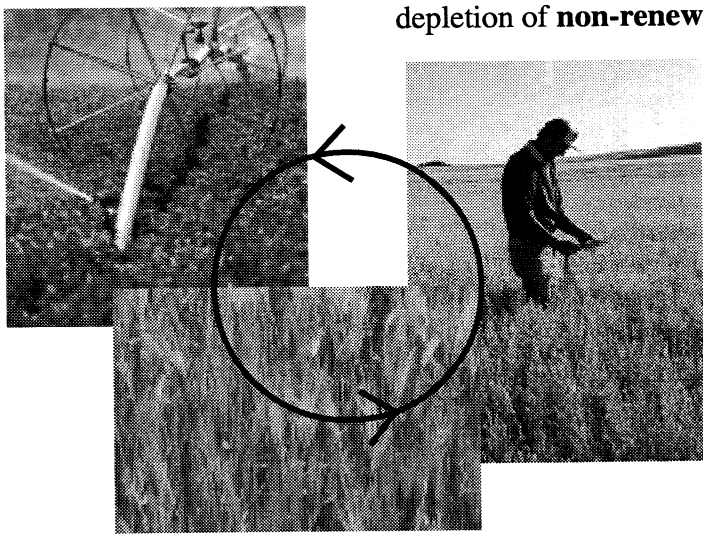

Figure 3: Rotating crops minimizes the loss of soil and nutrients.

Sustainable agriculture minimizes harmful effects of agricultural systems on the local environment, including the physical and biological resources surrounding the agricultural systems, as well as the landscape and more distant, potential receiving water bodies. This is often accomplished by minimizing the unintentional loss of indirect energy inputs and other farm resources off the farm. Many NRCS conservation practices, such as Nutrient Management, Pest Management, and Conservation Crop Rotation (Figure 3) are designed to do exactly this.

SOCIOECONOMIC VIABILITY

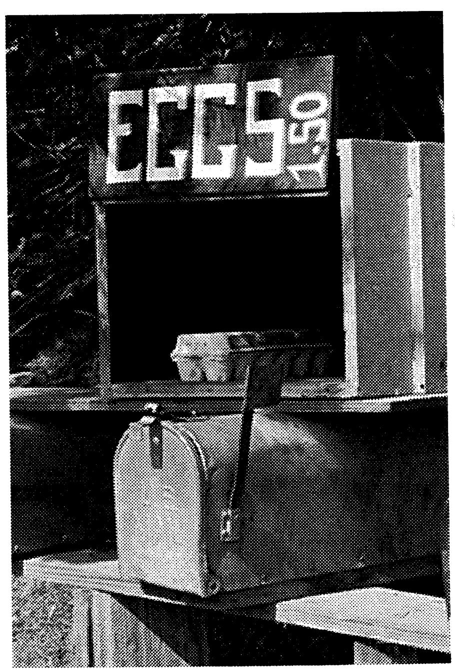

Figure 4: Sustainable farms often sell their products locally.

Sustainable agricultural systems are practical and economically viable approaches. Such systems involve reasonable risk and profit to the owners/operators based on the resources they have available. Sustainable agricultural systems are often more **diverse** than conventional agricultural systems. Diversity at first glance may seem to reduce efficiency and therefore profit; however, diversity in agricultural ecosystems, as in natural ecosystems, often reduces risk caused by external disturbance. Long-term profit can be stabilized and may be comparable to or higher than that of conventional agricultural systems. Sustainable agricultural systems also maintain economic viability of local communities and watersheds, exchanging dollars within a community, thus promoting the local economy and adding value to products (Figure 4).

Sustainable agriculture reflects local social values. A system that supports local people, not only sustains the community, but also promotes a vital support system and livable environment, both critical to quality of life.

SUSTAINABLE CHARACTERISTICS

Sustainable agricultural systems come in many sizes, shapes and colors. However, a number of characteristics seem to be common to many systems. Research Extension, North Dakota State University, (Gardner, 1995) suggests four identifying characteristics of sustainable farms: use of ecological niches, movable fences and livestock, crop diversity, and generally less capital-intensive operations.

Gardner defines a niche as "a distinctive habitat created by the land's slope, how much solar energy it receives, its relation to surface water and ground water, exposure to wind, or vegetation. To the farmer, a niche is an area where crops grow and yield differently." Each niche requires management that is unique. Sustainable farmers recognize diversity of place and manage their farms accordingly. In Montana, some farmers manage soils rather than fields. Others manage slopes and drainage ways. Still others create their own niches with selective plantings.

Sustainable systems often integrate livestock and cropping systems. With controlled grazing, animals are rotated often to utilize their impact on the land in a positive, cyclical manner. Temporary, movable fencing is an economical means of confining animals for rotational grazing and is often a visual indication of a sustainable agricultural system.

Sustainable farms tend to conserve nonrenewable energy. They use on-farm resources rather than purchased inputs

Diversity

Diversity is defined as "differences". In agricultural ecosystems these differences may be biological, social or economic and may be measured at different scales, from microbial to field, farm, landscape, regional and global (Olson & Francis, 1995). Agricultural diversity may include different crops, types of livestock and presence or absence of hedgerows and/or riparian areas. Diversity measures must also consider farm and field sizes, demography and ethnic backgrounds of farming populations, ownership patterns and other sources of variation within the agricultural setting. It should be apparent that measuring agricultural diversity is complex, and further, is compounded when one considers the hierarchy of scales within which diversity can be measured.

Figure 5: Alley cropping, a form of strip cropping, increases crop species diversity.

Ecological Diversity is the variety of life and its processes (including living organisms), the genetic differences among them, and the communities and ecosystems in which they occur. Different crop species and varieties, diverse livestock and natural fauna, and functional interactions among them can all contribute to biological diversity (Figure 5). Examples include morphologically different crop species (e.g., shallow vs. deep rooted, tall vs. short,

Diversity continued . . .

woody vs. herbaceous, early maturing vs. late maturing) and their spatial and temporal distribution. Field designs such as strip cropping and intercropping increase diversity at the field and farm scale. At the landscape level, biological diversity is often measured by the number of different landscape elements (patches) present. The spatial arrangement of these patches and physiographic features such as drainage patterns, ridges, woody corridors, and habitat edges dictate the functional diversity of the landscape.

Economic diversity can also be measured at different scales. At the farm scale, it may be described by the number of different products on the farm, while at larger scales farms can be categorized in terms of economic characteristics such as net income class, or by categories of enterprises. Economic relationships within a region that demonstrate more linkages and interactions, such as farmers using multiple suppliers and markets (Figure 6), are more functionally diverse than economic relationships such as contract farming in which the producer deals only with one supplier and buyer.

Social diversity is often described in terms of different ethnic groups, gender, education, age class, experience and other factors (Flora et al., 1992), but functional social diversity depends on the interaction among the different groups. For example, a community whose different social groups interact through trade, shared community service, and shared experience is more functionally diverse than a community in which racial, economic or social segregation prevent these interactions (Figure 7).

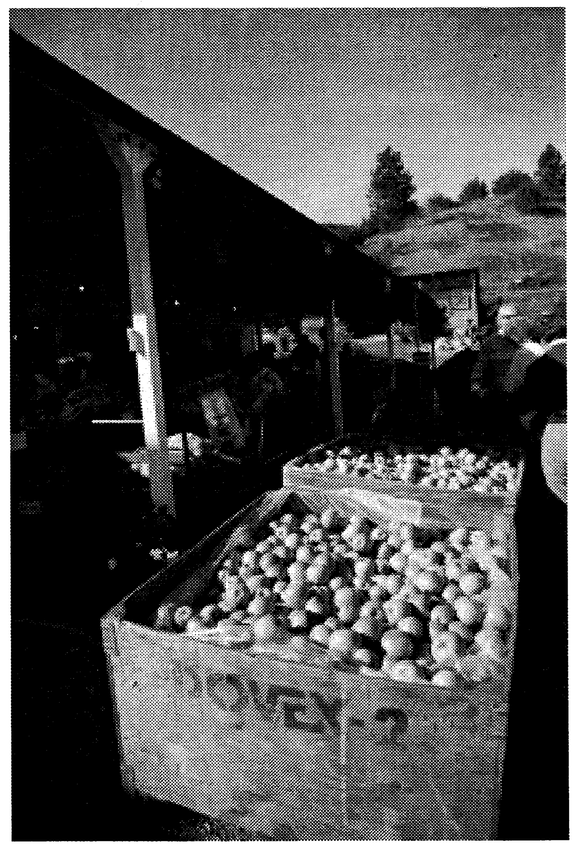

Figure 6: Farmer's market with a diversity of products for sale.

Figure 7: Community farmer.

when possible, and integrate biological cycles and controls where appropriate. In many places crop diversity is a critical element in sustainable farming. Alternating crops with different growth habits, nutrient requirements, and growing periods can utilize moisture and nutrients from different depths in the soil profile, break harmful pest and disease cycles, and harbor beneficial insects. Maximum utilization of resources is ensured while economically harmful pest populations are avoided. In some parts of the country this diversity is more important than in others, but in general crop diversity is an important key to sustainability.

Sustainable farms tend to use less imported energy and be less capital-intensive but more intensively managed than conventional farms. Sustainable farms are carefully designed to make optimal use of renewable resources with a minimal impact on the environment.

Diversity continued . . .

How is diversity related to sustainability? At the farm level, diversity of farm enterprises generally promotes stability if the farm enterprises are complementary. A diversified crop/livestock production system that recycles nutrients on the farm and adds value to crops by marketing them as animal products, may be more stable than a farm that is tied to external sources for energy, agrichemicals and debt. Long crop rotations that include only "nutrient mining" crops may not necessarily be stable.

Interactions between farms and the local community are necessary to promote stability of the next level. Communities in which goods and capital to support farm enterprises are internally exchanged are more stable than those dependent on outside suppliers of finances and goods. Community stability is increased by community control of local resources, diversification within the community, and maximum reliance on local production and markets. Interactions among communities are necessary to promote regional stability (Olson et al., 1995).

Figure 8: Irregularly shaped crop strips follow the natural contours of the land.

The layout of sustainable agricultural systems is visibly different from conventional systems in that fields are not necessarily rectangular. Rather, their shape reflects the niches they represent (Figure 8).

SUMMARY

Sustainable agriculture has been defined in many ways, but most definitions contain three common components: productivity, environmental quality and ecological function, and socioeconomic viability. Sustainable agriculture is profitable. It makes efficient use of nonrenewable resources and on-farm resources, and supports local communities. Energy conservation and diversity are two concepts often associated with sustainable agriculture.

The Natural Resources Conservation Service mission is to provide leadership and administer programs to help people conserve, improve and sustain our natural resources and environment. Sustainable agriculture is an important aspect of this mission.

CASE STUDIES

Case studies provide insights into how sustainable agriculture can work in the real world. Innovative farmers often develop new approaches to solving common problems. Case studies of these problems and solutions provide a means for others to see how innovative approaches can actually function in a farming system. In examining case studies it is important to remember that each situation is unique so that what works on one farm may or may not be a viable alternative for another. Still, case studies can help broaden the perspective of profitable alternatives and help focus future research (National Research Council, 1989).

Figure 9: Sustainable Agriculture Case Studies, (clockwise from top left: Mother Goose Farms, Hawaii; Ray Eck Farms, California; Lamar Black, Georgia; Kalin Farms, Nebraska).

Summarized here are four different alternative farming systems in which the farmers are striving toward sustainability (Figure 9). The farms vary in size from 7 acres to over 1,000 acres. They are located on opposite ends of the country, the crops grown are different, and the farmers' resources are different. They have at least two things in common, though, a desire to protect the resources on which they depend while maintaining productivity, and a willingness to try methods previously untested to achieve their goals. More detailed case study descriptions are provided as inserts.

Summary of Case Study 1: Mother Goose Farms

Mother Goose Farms is a small, organic coffee farm in South Kona, Hawaii. The owners, John and Vicki Smith have successfully eliminated herbicide and insecticide inputs by using geese as biological control agents. The geese also help cycle nutrients in the orchard. The Swifts are experimenting with alley cropping of the tropical legume, gliricidia, as a means of providing added protection and nutrients for the coffee plants. They have cornered a niche market for their organic coffee, which they process on site and sell locally, thereby eliminating energy costs associated with transportation. Mother Goose Farms is small but thriving.

Summary of Case Study 2: Ray Eck Farms

Ray Eck grows organic almonds in Merced County, California and uses natural biological interactions to control insects and weeds. He cultivates a cover crop under almonds as part of this agricultural ecosystem. It provides habitat for beneficial insects and wildlife, controls undesirable plants, cycles water and nutrients, and improves soil quality. Ray carefully monitors the moisture and nutrient status of crops and maintains them at an optimal level. He shares his knowledge of biological interactions with other farmers through the BIOS (Biologically Integrated Orchard Systems) program, designed to help fruit and nut growers reduce chemical inputs while maintaining profitability.

Summary of Case Study 3: Lamar Black

Lamar Black grows a variety of row crops on 1,000 acres in east central Georgia. He uses strip-till for all of his crops. This minimum tillage system reduces erosion, improves soil quality, reduces fuel costs, and improves wildlife habitat. Lamar is frugal with inputs such as irrigation water, fertilizers and pesticides, applying only when needed and only as much as needed. He plants pest-resistant crop varieties and uses winter cover crops for erosion control and improved soil fertility. He belongs to a cotton cooperative which helps him market that crop, but he markets other crops himself. The variety of crops he plants helps him weather fluctuating crop prices and maintain a steady cash flow. Lamar's strong stewardship ethic transcends ownership, since he does not own the land he farms.

Summary of Case Study 4: Kalin Farms

Ed and Dorothy Kalin run a cow/calf operation on 1,160 acres of land in southeast Nebraska. Erosion is a major concern. Three quarters of the farm is in permanent pasture. The Kalins contour till the remaining cropland. The farm contains 8-10 miles of terraces, 2 miles of grassed waterways and 12 farm ponds that are or will soon be fenced. In addition, the farmstead and livestock wintering areas are protected by mature shelterbelts. The Kalins use rotations and fertility management to help control weeds and insect pests. They are energy conscious and make an effort to reuse or recycle farm materials. The Kalins apply different strategies to stabilize cash flow in the face of fluctuating market prices. These include sale of excess crops, value added enterprises, and minimization of capital costs by reducing waste and making efficient use of assets.

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